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Editorial Comment

Anatomy of Atrioventricular Attachments, Connections and Junction: *In Medio Stat Virtus**†

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In an original article published in this issue of the Journal, Dean et al. (1) describe the clinical anatomy of the atrioventricular (AV) junctions. They discuss the septal area and its adjacent regions in an attempt to clarify the complex anatomy as well as confusion due to misleading terminology. The complex membranous attachment between the atrial and ventricular myocardium is currently routinely approached using endocardial catheter techniques to ablate the anatomic arrhythmogenic substrate of either the Wolff-Parkinson-White syndrome and its variants or the AV node reentrant tachycardias. Therefore, a good understanding of the anatomy is paramount for comprehensive communication between electrophysiologic interventionists and to achieve rapid adequate positioning of the ablative catheter.

Definition of terms. The AV *junction* refers to the AV myocardial continuity that allows atrial impulses to be transmitted to the ventricular myocardium—the normal AV node–His bundle system. The Wolff-Parkinson-White syndrome and its variants are associated with myocardial AV accessory *connections* distinct from the normal AV node–His bundle system and which allow the atrial or ventricular impulses, or both, to bypass the normal AV junction. The actual anatomic *attachment* between the atrial and ventricular myocardium is attained by a complex membranous structure that bridges and separates the two distinct myocardiums. This membranous structure comprises the AV annuli (laminae) and the aortic annuli with the appended cuff of the aortoventricular membrane (2).

The AV attachment. Dean et al. (1) used dissection and an analytic approach to describe the anatomy. A more synthetic approach, constructing the AV attachment from its elementary parts (Fig. 1), might be useful to the reader.

The atrial myocardium presents with two AV orifices that circumscribe the two homologous AV ventricular orifices. The two atrial orifices are distinct and are not in the same plane. The "tricuspid" orifice is anterior to the mitral valve orifice.

The ventricular myocardium is composed of the conical left ventricular mass and the attached right ventricular free wall myocardium. The left ventricular myocardium presents with a single orifice: the left ventricular ostium (2). Two orifices open into the left ventricular ostium, the aortic orifice and the mitral valve with its complex apparatus. The presence of the aortic orifice and its appended membranous attachment to the left ventricle accounts for the complex anatomy of the region.

The three scalloped aortic annuli are attached to the left ventricular ostium by the aortoventricular membrane, which is essentially a quasi-cylindric membranous cuff, appended inferiorly to the annuli, and taking part in the construction of the left ventricular outflow tract. The aortoventricular membrane comprises six parts: 1) the membranous septum between the right and posterior annuli; 2) the right fibrous trigone, which is not the triangular but the cordlike posterior side of the atrial membranous septum that attaches the posterior aortic annulus to the left ventricular ostium; 3) the intervalvular trigone, which is a membrane between the anterior mitral valve leaflet and the aortic annuli; 4) the left fibrous trigone; 5) the anterior trigone; 6) the mitral valve annulus or lamina (filum of Henle). The circumference of the mitral valve orifice is composed of the mitral valve lamina, the ventricular attachment of the right fibrous trigone, the edge of the intervalvular trigone and the left fibrous trigone. The circumference of the tricuspid valve orifice consists of the tricuspid valve anulus, which attaches over either the right ventricular free wall or the interventricular septum, and the membranous septum, which is divided into two segments by the tricuspid valve orifice.

The AV attachment is divided into two segments: the annular segment, which includes the mitral valve and tricuspid "anulus," and the nonannular segment, which includes the membranous structure appended to the aortic annuli.

The annular attachment. The atrial myocardium attaches onto the mitral valve and tricuspid valve annuli. The annulus is, on macroscopic dissection, a membranous lamina that attaches and separates the two myocardium and gives rise to the leaflets (2). Neither the tricuspid nor mitral valve annulus spans the entire AV orifice. The mitral valve annulus is interrupted along the intervalvular trigone between the right and left fibrous trigone. The tricuspid annulus is interrupted over the atrial membranous septum where the membranous segment of the septal leaflet attaches. The mitral and tricuspid valve annuli do not come into contact because the tricuspid valve attaches onto the atrial membranous septum and left ventricular septum, and the mitral valve annulus attaches onto the edge of the left ventricular ostium posteriorly. The segment of the left ventricle between the mitral and tricuspid valve attachments is termed the posterior superior process of the left ventricle (2). Because the distance between the two annuli over the membranous septum is short, the two annuli appear to meet (what pathologists call the central fibrous body). Superiorly, the two AV annuli are widely separated by the aortic orifice. The mitral and tricuspid "annuli" are constituents of the AV sulcus, which is the fat-filled groove between the atria and the ventricles, and

*Virtue stands in the middle.

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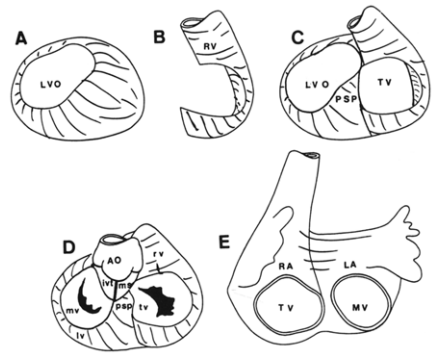

Figure 1. Construction of the atrioventricular (AV) attachment. **A,** Left ventricular unit with its single orifice. **B,** Right ventricular free wall. **C,** Attachment of the right ventricular free wall to the left ventricular unit and formation of the tricuspid orifice. Also delineated is the posterior superior process of the left ventricle, which is used to construct the AV myocardial septum. **D,** Implantation of the aortic annuli and the ventroventricular membrane. Shown are the membranous septum, the intervalvular trigone and, between the two, the right fibrous trigone, which attaches the aortic annulus to the left ventricular ostium. **E,** Anterior view of the atria with their AV orifices widely separated, as such orifices are (see D). AO = aorta; ivt = intervalvular trigone; LA = left atrium; lv = left ventricle; LVO = left ventricular ostium; ms = membranous septum; MV, mv = mitral valve; PSP, psp = posterior superior process of the left ventricle; RA = right atrium; RV, rv = right ventricle; tv = tricuspid valve.

are roofed by the pericardium. The AV sulcus encircles the base of the ventricles but is interrupted superiorly by the aortic orifice. The AV sulcus provides an imperfect reference point. Its shape and size vary in different locations, and its upper and lower margins, the lines of pericardial reflection, vary with the amount of fat present. The AV sulcus is interrupted anteriorly (superiorly) by the aorta. Its semicircular crown spans from the right side of the aortic root (right coronary fossa) to the left side of the aortic root (left coronary fossa). It has been well described by anatomists. Its groove presents with simple anatomic features laterally. Its cross section is triangular, with the apex to the AV ring and the sides formed by homonymous atrial and ventricular wall. In the region of the so-called crux (posterior septal region), which is not a punctual intersection because of the presence of the posterior superior process of the left ventricle, the AV sulcus is a groove between the right atrial wall and the left ventricle, with the apex formed not by a membranous annulus but by the junction of the right atrial wall with the posterior process of the left ventricle (edge of the AV myocardial septum). Because the AV accessory connections were, in the early days of surgical ablation, thought to be exclusively located within the AV sulcus, bypassing the AV annulus, Sealy and colleagues (3–5) described an anatomic and surgical classification of the accessory connections based on the division of the AV sulcus in four regions: left free wall region, including the left coronary fossa; posterior septal region (region of the crux or pyramidal space); right free wall region; and anterior septal region (right coronary fossa). The qualifier "septal" meant that the regions were anterior to or posterior to the septum. Because these regions were medial, situated within the same geometric plane as the septum, the label produced some confusion. However, a space between the cardiac walls could not in any way be a septal structure.

The nonannular attachment. The nonannular attachment utilizes the membranous structures appended to the aortic annuli (left ventricular outflow tract). The right atrial wall attaches to the membranous septum, and the left atrial wall attaches to the intervalvular trigone. Both atria (interatrial septum), which sandwich the AV node, attach onto the right fibrous trigone (central fibrous body). Only the atrial membranous septum is a true septal structure. However, surgical dissection has led us to revisit the definition and our concept of the structure of the septum of the heart.

The septum of the heart. The septum of the heart is composed of three segments: The medial segment is the triangle of Koch, which separates the interventricular septum from the interatrial septum. Koch understood the importance of the triangle in cardiac anatomy. The triangle's posterior side is the tendon of Todaro, which prolongs the eustachian valve and attaches onto the central fibrous body. The base has no discrete limits but is a horizontal line above the coronary sinus where the right atrial wall diverges from the posterior process of the left ventricle (AV myocardial septum). The triangle of Koch comprises three segments: the atrial membranous septum at the apex (purist's AV septum); the AV myocardial septum anteriorly (posterior process of the left ventricle); and the AV nodal region posteriorly (compact and intermediate node). The entire triangle of Koch, as described, should be considered a septal structure.

The AV myocardial septum. The AV myocardial septum is formed by two apposed walls: the posterior process of the left ventricle and the inferior wall of the right atrium. The interventricular septum is well defined by the attachment of the right ventricular free wall and the septal tricuspid leaflet onto the left ventricle. The ventricular septum includes the membranous ventricular septum, which is anterior to the atrial

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membranous septum. The myocardial ventricular septum is extended posteriorly and inferiorly by the posterior superior process of the left ventricle, which has the characteristics of a septal wall. The right atrial "septal" wall is apposed and covers the posterior superior process of the left ventricle in its upper segment. Inferiorly, the right atrial wall and the left ventricular process diverge to form the posterior septal region. That region of the AV septum is regarded by electrophysiologic interventionists as a specific area—the midseptum. The term *midseptum* is a very apt description because the AV muscular septum is situated between the true atrial and ventricular septa.

The coronary sinus. The coronary sinus is a remnant of the left superior vena cava, which collects the left cardiac veins (i.e., midcardiac and great cardiac veins). The coronary sinus os is not in close relation with the AV attachment. The coronary sinus courses posterior to the posterior septal region. There would be no reason to include the coronary sinus in the clinical anatomy of the AV attachment and junction, if experience had documented its special role in two ways: 1) the coronary sinus os and the coronary sinus itself allow the endocardial catheter to circumscribe the mitral valve orifice; 2) the coronary sinus itself and its afferent branches can be the anatomic substrate for accessory AV connections. Guiraudon et al. (6) have described the significance of the coronary sinus diverticulum. Investigators using catheter techniques have recently documented (7) that the coronary sinus and its branches can harbor or be closed to the AV accessory connections.

Conclusions. Although pathologists, surgeons and electrophysiologic interventionists use very different approaches and tools to observe the anatomy of the AV attachments, connections or junctions, there is currently a remarkable consensus among the various disciplines that has led to the remarkable successes achieved by the electrophysiologic interventionist.

References

1. Dean JW, Ho SY, Rowland E, Mann J, Anderson RH. The clinical anatomy of the atrioventricular junctions. J Am Coll Cardiol 1994;24:1725–31.
2. McAlpine WA. Heart and Coronary Arteries. New York: Springer-Verlag, 1975:9–26, 86.
3. Sealy WC, Gallagher JJ, Pritchett ELC. The surgical anatomy of Kent bundles based on electrophysiological mapping and surgical exploration. J Thorac Cardiovasc Surg 1978;76:804–15.
4. Sealy WC. Kent bundles in the anterior septal space. Ann Thorac Surg 1983;36,2:180–6.
5. Sealy WC. The evolution of the surgical methods for interruption of right free wall Kent bundles. Ann Thorac Surg 1983;36,1:29–36.
6. Guiraudon GM, Guiraudon CM, Klein GJ, Sharma AD, Yee R. The coronary sinus diverticulum: a pathological entity associated with the Wolff-Parkinson-White syndrome. Am J Cardiol 1988;62:733–5.
7. Arruda MS, Beckman KJ, McClelland JH, et al. Coronary sinus anatomy and anomalies in patients with posteroseptal accessory pathway requiring ablation within a venous branch of the coronary sinus [abstract]. J Am Coll Cardiol 1994;23:224A.